Predicting *Pomacea dolioides* (Reeve)

(Prosobranchia : Ampullariidae)

Weights from Linear Measurements of Their Shells

BY

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INTRODUCTION

THE AMPHIBIOUS PROSOBRANCH, *Pomacea dolioides,* is common in freshwater marshes of coastal northeastern South America (PAIN, 1950; GEIJSKES & PAIN, 1957). It is the primary food of the snail kite *(Rostrhamus sociabilis)* in Guyana, South America (SNYDER & SNYDER, 1969). While working on the feeding ecology of the snail kite in Guyana (BOURNE, 1982), it was necessary to handle large numbers of live *P. dolioides* and their discarded shells. Empty *P. dolioides* shells can be collected from under kite perches and if necessary their body weights can be estimated from linear dimensions, *e.g.,* in order to determine energy budgets for snail kites. Before body weight estimation is possible from discarded shells the relationship between weight and linear measurements of live snails from the same population as the discarded shells must be established. Several investigators, including MENGE (1971), CAMERON & CARTER (1979), GUEDES *et al.,* (1981) and McLACHLAN & LOMBARD (1981) have predicted body weights of gastropods from linear measurements. We report the results of the relationships of linear dimensions to body weights for 1531 *P. dolioides* collected at 5 locations within coastal Guyana, from 5 habitat or patch types during 1980.

MATERIALS AND METHODS

Study Sites and Patch Types: We collected *Pomacea dolioides* in the Botanical Gardens (6°50′N; 58°09′W) and the Guyana National Park (6°50′N; 58°10′W), Turkeyen (6°50′N; 58°08′W), Vryheid's Lust (6°50′N; 58°06′W), and Burma (6°28′N; 57°45′W), Guyana. All of these locations are on the eroded coastal flood plain bounded by the Abary River on the East and the Demerara River on the west. Several other rivers and drainage canals dissect the landscape and discharge their waters into the Atlantic Ocean to the north. Descriptions of the climate, geology, flora and fauna of Guyana's coast are available in HARRISON *et al.* (1913), PAIN (1950), GIGLIOLI (1959), CUMMINGS (1965), SNYDER (1966), and POONAI (1970).

Five snail habitat or patch types were defined as follows: (1) shallow drainage ditches <0.5m deep and <1m wide (little ditch); (2) shallow drainage ditches <1m wide (big ditch); (3) ponds of varying areal coverage, but <1m deep (pond); (4) natural sedge and grass wetlands with water depths varying from 80mm to 0.5m (meadow); and (5) flooded ricefields with varying water depths of 105 to 250mm (ricefield).

Sampling and Measuring: Snails were sampled from June to November 1980. We used modifications of WIENS' (1969) line transect method to obtain restricted random samples. Only visible *Pomacea dolioides* at or near the surface of turbid water were gathered by hand at each sample point. Spat sized individuals (<10mm wide or <0.25g whole fresh weight) were ignored. This was done to simulate the visual hunting behavior of the snail kite. About 100 snails were taken from each patch type present at each location.

The snails were dried and cleaned of adhering matter with laboratory paper towels. Height (the distance between the shell apex and the lower margin of the peristome) and width (the maximum shell diameter) were measured to the nearest 1mm by dividers and metric ruler. Weights were recorded for each snail on a 30g or 100g spring scale to the nearest 0.25g. A total of 1479 *Pomacea dolioides* were processed.

Fifty-two snails were collected on 5 November from a big ditch in the Guyana National Park. Individuals visually judged to be smaller than the mean size taken by snail kites were ignored. Shell measurements and whole fresh weights were recorded. The soft tissue was excised by severing the columellar muscle with a sharply decurved piece of wire and the operculum was removed. Individuals were sexed by inspection of gonads. The tissue mass was blotted dry in filter paper and fresh weights recorded to the nearest 0.01g. Dry weights to the nearest 0.01g were

obtained after oven drying at 60°C for 48 hours. We dropped 7 snails from this sample because it was impossible to get all of the soft tissues out of their shells. Therefore, statistical analyses were performed on 45 snails.

Statistical Methods: We used conventional least squares regression methods to explore relationships among the various parameters. Regression was used to test for the significance of the linear relationships between the pertinent variables and to develop equations which might be useful for predictive purposes. Analysis of covariance was used to compare regression equations from different populations. Residual analysis was performed in all cases to test the assumptions of the regression and analysis of covariance models.

The relationship between length and weight of some organisms is commonly expressed as a logarithmic function (*e.g.*, Ricker, 1975). The equation relating length to weight takes the form: weight = e^{α} length$^{\beta}$, where α and β are the parameters of the model for a given population of organisms. This equation may be expressed in linear form as follows: $\log_e$ weight = $\alpha + \beta \log_e$ (length). This will be referred to as a log-log regression.

Expressions were developed separately for each patch type within each location, yielding a total of 14 individual regressions. These regressions were then compared across patch types (within location) using the analysis of covariance (Neter & Wasserman, 1974).

A sample of 45 snails was obtained from the pond patch type within the Guyana National Park. Data from this sample were used to develop predictive equations for the dry weight of an individual based on whole fresh weight or width. Equations were developed for the entire sample and separately for males and females. The equations for males and females were compared using analysis of covariance.

RESULTS

The α and β parameters along with R^2 values for the regressions are summarized by location and patch type (Table 1). Analysis of residuals showed no significant departures from the assumptions of the regression model. The lowest R^2 value for any regression equation was 0.88 (Burma, big ditch) (Table 1), and all regressions were significant below the 0.0001 level. Thus, the log (length)-log (weight) model commonly applied to problems of scaling in the evolution of animal size and to fisheries allometry (e.g., Gould, 1966, 1971; Ricker, 1971, 1975) appears to hold quite well for *Pomacea dolioides*, and this relationship may be used to predict whole weight from width with a high degree of confidence. Tolerance intervals indicate that actual predictive precision is best at or near the mean.

Analysis of covariance indicated that for 3 locations (Botanical Gardens, Guyana National Park, and Vryheid's Lust) the regressions were clearly different across patches. For the remaining 2 locations (Burma and Turkeyen), the hypothesis of equal regressions could be accepted marginally. However, combining regressions meant a reduction in R^2 values and an increased standard error (SE)

Table 1

Log-log regressions of width on weight for coastal Guyana *Pomacea dolioides*, June-November 1980.

Location	Patch	N	α	β	R^2*	SE***
Burma	Big Ditch	102	−7.51	2.73	0.88	2.64
	Little Ditch**	77	−7.91	2.85	0.90	2.13
	Meadow	103	−8.09	2.89	0.93	3.37
	Ricefield	103	−7.94	2.84	0.92	3.56
Botanical Gardens	Big Ditch	116	−8.59	3.01	0.95	2.77
	Little Ditch	117	−8.30	2.92	0.93	2.29
	Meadow	112	−8.32	2.92	0.97	1.99
	Pond	110	−8.15	2.90	0.95	3.01
Guyana National Park	Big Ditch	122	−8.62	3.00	0.94	2.87
	Pond	103	−7.87	2.83	0.93	3.38
Turkeyen	Big Ditch	103	−8.26	2.91	0.93	2.99
	Meadow	104	−8.18	2.90	0.93	3.20
Vryheid's Lust	Big Ditch	106	−7.58	2.72	0.98	1.20
	Meadow	101	−6.70	2.50	0.90	3.51

*$P < 0.0001$ in all cases.

**Really the Rice Research Station at Burma.

***R^2 and SE expressed in terms of the raw data by antitransforming predicted values.

Table 2

Log-log regressions of whole weight on dry weight and width on dry weight for 18 male and 27 female *Pomacea dolioides* collected at Guyana National Park, Georgetown, 5 November 1980 from a big ditch.

Sex	Variables	α	β	R^2**	SE***
Male	WW on DW*	−2.73	1.02	0.75	0.18
Female	WW on DW	−2.27	0.91	0.62	0.18
Male	W on DW	−9.36	2.49	0.56	0.24
Female	W on DW	−8.31	2.26	0.50	0.20
Both	WW on DW	−2.75	1.04	0.76	0.18
Both	W on DW	−10.09	2.70	0.63	0.22

*WW = whole weight, DW = dry weight, W = width.

**P <0.0001 in all cases.

***R^2 and SE expressed in terms of the raw data by antitransforming predicted values.

in some cases. For predictive precision, then, it was decided to let the separate regressions stand.

Regressions were also developed within the sexes to relate dry weight to whole fresh weight or width. As far as predictive ability and meeting assumptions are concerned $\log_e$ (dry weight) versus whole fresh weight, and $\log_e$ (dry weight) versus $\log_e$ (whole fresh weight) performed equally well (Table 2). However, the analysis of covariance indicated that only the $\log_e$ (dry weight) − $\log_e$ (whole weight) regressions could be combined across sex, making this the more useful relationship (Table 2). When the regression is developed ignoring sex, the equation is: dry weight = $e^{-2.75}$ (whole fresh weight)$^{1.04}$. This regression was significant (Table 2).

The regression derived to relate dry weight to width also took a log-log form (Table 2). The equation was dry weight = $e^{-10.09}$ (width)$^{2.70}$. However, the analysis of covariance indicated that the intercepts for the regressions by sex were not equal. This means an overall equation, although possibly still useable, would show a consistent bias in prediction depending on the sex of the individual.

DISCUSSION

At 3 locations (the Botanical Gardens, Guyana National Park, and Vryheid's Lust) cross patch comparisons of the width-weight relationships indicated significant differences, while comparisons at Burma and Turkeyen showed no significant differences in relationships. Apparently there are 4 major reasons for these patch to patch differences. The reasons discussed below may or may not be mutually exclusive.

Firstly, some patches completely dry up in the late dry season (September to November 1980), *e.g.*, the big ditch and meadow at Vryheid's Lust, little ditch and meadow in the Botanical Gardens, and some meadows and ricefields at Burma. In the absence of standing water *Pomacea dolioides* aestivates. This affects growth patterns (Burky, 1974) and probably influences changes in surface area to volume relationships (Gould, 1971). Secondly, although snail food availability was not measured, the big ditches and ponds in the Botanical Gardens and Guyana National Park appeared to provide abundant year-round supplies of aquatic algae and *Nymphaea* spp. lilies, whereas the other patches in other locations appeared to provide food in flushes, influenced by water availability. Thirdly, as this study indicates, there are sexual weight differences. It has also been shown that females with maturing eggs weigh more than the mean for their shell dimensions (Guedes *et al.*, 1981). If a sample from a particular patch is biased towards females with maturing eggs, significant differences across patches could be expected. This coupled with the fact that reproductive regimes vary from patch to patch because of water availability problems. Thus, we would expect varying stages of egg maturation to account for some of the significant differences in width-weight relationships across patches. Finally, we cannot rule out effects due to differences in collection dates. This could produce differences in the measurement-weight relationships through an aging effect. Similar intraspecific size related differences due to age have been reported for fishes (Ricker, 1971, 1975), and gastropods (Geldiay, 1956).

SUMMARY

In Guyana, South America, the amphibious prosobranch, *Pomacea dolioides* (Reeve), is very common in coastal freshwater marshes, ricefields, drainage and irrigation ditches, and ponds. From June to November 1980, 1531 *P. dolioides* were collected and weighed and their shells were measured to elucidate the relationships between linear measurements, whole fresh weights and excised dry weights.

The snails were collected at the Botanical Gardens, Guyana National Park, Turkeyen, Vryheid's Lust and Burma from 5 patch types, i.e., little ditches, big ditches, ponds, meadows, and ricefields. Least squares regressions indicated the significance of the linear relationships of the measured variables and allowed us to develop a predictive equation of the form $\log_e$ (weight) = $\alpha + \beta \log_e$ (width), where α and β are coefficients of the equation derived from the regressions.

Whole fresh weights were predicted from width measurements of shells, but there were location and patch differences. Therefore, separate regressions were used for each

location and patch to improve predictive precision. Sexual differences were also found for 45 snails that were sacrificed, sexed, and their flesh dried. However, $\log_e$ (dry weight) against $\log_e$ (whole fresh weight) regressions could be combined across the sexes. This relationship is more useful for studies where destructive sampling is not desirable or is impossible.

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